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SIMULATION OF THE CERAMIC BALL FORMATION

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ABSTRACT

Nowadays, ceramic ball is commonly used as catalyst support in the chemical industry. However, ceramic balls production has not being widely study yet. This is because it is difficult and expensive to study the production of ceramic balls from the plant instead simulation study is necessary to carry out. Therefore, this project is carried out to develop mathematical modeling from the ceramic balls production and to validate the parameters from the experimental work data with the simulation data based on simulation software. Actually, simulation can improve the system performance by changing the model parameter. Therefore, in this project, the mass, volume and radius parameter will be study. Firstly, mathematical modeling of the ceramic ball production must be developing and then simulation model can be developing by using MATLAB software. Then, run the simulation model and identify whether the result is validate with mathematical modeling or not. If not, refers to the mathematical model back and if validate, end the simulation. From this research, it is expected to result in mathematical modeling in the ceramic ball production. By using simulation also one will reduce time, cost, and disruption of experimenting on the actual system. Then, experiments are too expensive, too dangerous, and the system to be investigated does not yet exist but by using simulation all variables can be studied and control and it is easy to manipulate the parameters.

SIMULASI DARIPADA PEMBENTUKAN BOLA SERAMIK

ABSTRAK

Pada hari ini bola seramik biasanya digunakan sebagai pemangkin sokongan dalam industri kimia. Walau bagaimanapun, pengeluaran bola seramik tidak dipelajari secara meluas lagi. Ini adalah kerana ia adalah sukar dan mahal untuk mengkaji pengeluaran bola seramik dari industri melainkan kajian simulasi adalah perlu dijalankan. Oleh itu, projek ini dijalankan untuk membentuk model matematik daripada pengeluaran bola seramik dan untuk mengesahkan parameter daripada data kerja eksperimen dengan data simulasi berdasarkan perisian simulasi. Sebenarnya, simulasi boleh meningkatkan prestasi sistem dengan menukar parameter model. Oleh itu, dalam projek ini, parameter seperti berat,isipadu dan jejari akan menjadi kajian. Pertama, pemodelan matematik berdasarkan pengeluaran bola seramik harus dibentuk dan oleh itu model simulasi boleh dijalankan dengan menggunakan perisian MATLAB. Kemudian, jalankan model simulasi dan mengenal pasti sama ada keputusan adalah tepat dengan model matematik atau tidak. Jika tidak, rujuk kepada model matematik semula dan jika disahkan, tamatkan simulasi. Daripada kajian ini, ia dijangka pembentukan dalam pemodelan matematik daripada pengeluaran bola seramik. Dengan menggunakan simulasi juga seseorang akan mengurangkan masa, kos, dan gangguan bereksperimen pada sistem sebenar. Kemudian, eksperimen adalah terlalu mahal, terlalu berbahaya, dan sistem yang akan dikaji belum wujud tetapi dengan menggunakan simulasi semua pembolehubah boleh dikaji dan dikawal dan ia adalah mudah untuk memanipulasi parameter.

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LIST OF SYMBOLS

cm	Centimeter
Fin	Mass Flowrate Inlet
Fout	Mass Flowrate Outlet
g	Gram
h	Hour
m	Mass
mm	Milimeter
r	Radius
V	Volume
p	Density

LIST OF ABBREVIATIONS

EIS PACK	Eigen System Package
HIP	Hot Isostatic Processing
LINPACK	Linear System Package
MATLAB	MATrix Laboratory

CHAPTER 1

INTRODUCTION

1.1 Research Background

Ceramic ball are made from inorganic and non-metallic compounds. It is very hard, resistant to abrasion and insusceptible to all furnace atmospheres. Their shape is spherical and their rolling elements provide higher stiffness, lower thermal expansion, lighter weight, increase corrosion resistance and higher electrical resistance than steel balls. This is because they are made from a variety of ceramic materials. This is supported by Jeon (2012), which said that ceramic balls made of a variety of difference ceramic materials. The materials include alumina, alumina-zirconia, aluminium nitride, and aluminium silicate; boron nitride; and silicon carbide; and zirconia, and zirconium phosphate. Therefore, from this, supplier can choose the best material to produce ceramic ball which can be related to their application. For example, ceramic ball which used to support the catalyst bed in the reactor. It must have a characteristic of lower thermal expansion, very hard and insusceptible to all furnace atmospheres. This is because it was used to prevent the loss of catalyst downstream of reactor vessel during the high temperature and also high pressure in the reactor vessels.

In order to study and validate the parameters that involve in a ceramic ball production, a simulation process will be carried out. Actually, simulation is the use of mathematical model to recreate a situation, often repeatedly, and from this a several of possibility outcomes can be more accurately estimated. According to Harell (2000), simulation is the process of designing a model of a real system and from this model, someone will be able to conduct an experiments for the purpose either of understanding the behavior of the system or evaluating a various strategies for the operation of the system. This is because a mathematical modeling must be developing first before conduct the experiment using the simulation. This model represents the key characteristics or behaviors of the selected physical or abstract system or process. The model also represents the system itself but the simulation represents the operation of the system over time. Then, from this mathematical modeling, you can do try and error in order to select the best types of simulation for your model. Lastly, you can make a comparison between the result from the simulation and from the experimental data.

Ceramic balls production has not been widely studied yet by the researchers. This is because this topic is new and not all of us know about the ceramic balls. However, the concept of ceramic balls production has the equivalence with the crystallization process. For example, in the rate of crystal growth in which when time increase, the crystal form become bigger and bigger. So, someone will know the velocity of crystal growth form at certain time.

1.2 Problem Statement

There are a few problems involve which leads to this research in which it is difficult and expensive to study the production of ceramic balls from the plant instead simulation is necessary to carry out. This is because in order to run the experiment, one must buy the material, apparatus and many others. Then, if the result is not accurate or not efficient, one must repeat the experiment again and again until they get the accurate result. Therefore, experiment will take a long time and need more cost to buy the others material. However, by using the simulation, they can only do try and error in order to get the result and will used the simulation software only. From this, one will save the budget and also will reduce the time. Other than that, ceramic ball has not being widely study yet. Therefore, I take this opportunity to carry out this research but it is difficult to find the source in order to run the simulation.

1.3 Research Objective

The purpose of this study is to develop mathematical modeling from the production of ceramic ball. The second objective is to validate the parameters from the experimental work data with the simulation data based on the simulation software.

1.4 Research Question/Hypothesis

1.4.1: How to develop mathematical modeling from the ceramic balls production?

1.4.2: How to validate the parameters from the experimental work data with the simulation data?

1.5 Scope of the Proposed Study

In order to achieve the objective of this research, the following scopes have been identified. First, ones need to know how to develop mathematical modeling in order to run the simulation process. Then, one needs to know how to analyst and compare between the data from the simulation software with the experimental data.

1.6 Expected Outcomes

The results of this study is one will be able to develop mathematical modeling based on the parameters that involve in the ceramic ball production. Then, one can be able to study and validate the data from the experimental work data with the simulation software.

1.7 Significance of the Proposed Study

With the presence of modern technologies, this research will give many advantages to the technology, engineering and education. Firstly, it will save our time because the time scale of the dynamics of the system is not compatible with that of the experimenter. For example, it will take a millions of year to observe small changes in the development of universe, but similar change can be quickly observed via computer simulation. Then, experiments are too expensive, too dangerous or the system to be investigated does not exist yet. There are the main difficulties of the experimentation with the real system.

Besides, by doing experiment, the variables may be inaccessible. Compare to the simulation, all the variables can be studied and controlled even these that are inaccessible in the real system. Lastly, it is an easy manipulation of models. By using simulation, it is easy to manipulate the parameters of a system model, even outside the feasible range of a particular physical system.

1.8 Conclusion

In this research, a mathematical modeling for the validation of parameters model will be developed and one will able to analyze, validate and compare between the experimental work data with the simulation data based on the simulation software.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Ceramic Ball

Ceramic are defines as a class of inorganic, nonmetallic solids that are subjected to high temperature in manufacture or in use. Ceramic processing generally involves high temperatures, and the resulting materials are heat resistant or refractory. Actually, according to Indiani et.al (2012), the word of ceramic comes from the Latin word which is 'Keramos' meaning pottery or utensils made of clay which undergo sintering process. The earliest raw material used is clay. Clay is defined as a coherent and become attached when mixed with water. When wet it is easy to set up but if it is dried it becomes hard and brittle and also will maintain its shape.

Ceramic raw materials such as kaolin, feldspar and silica and other materials are mixed with a certain ratio, then processed and burned which eventually produces ceramics industry. During burning process, these materials interact with each other to form a product with different characteristics. According to Jeon (2012), Ceramics are generally produced in the form of ceramic balls, which produce alkaline water having good and soft taste to drink, when used for water purification. Ceramic ball began to be widely used for the filtration of drinking water in the 19th century. Thus, the ceramic balls are used in a variety of fields for household, industry, agriculture and stockbreeding, such as water ionizers, filters for bidets, humidifiers, water purification and processing devices for washing, bathing, and the like, as well as water purifiers.

Ceramic ball also known as inert balls, catalyst support ball, alumina balls, high-alumina balls, filter material and bed support. This is supported by Rakannusa (2012), which stated that ceramic ball is also known as inert ball and catalyst support media. It was called catalyst support due to the function that acts as catalyst to prevent the problems that occur in the reactor during their operation. Therefore, ceramic ball will act as a savior to packing material and also to back up catalyst bed in order to avoid the discovery or loss of the catalyst or adsorbent materials downstream of the reactor vessels in consequence of the high pressure and temperature inside the reactor vessels during the operation. Ceramic is also an ideal filter medium because it has a small and complex pore structure. Actually, ceramic ball consist of different size, which are 3mm, 6mm, 10mm, 13mm, 19mm and 25mm. The size was arranged from layer to layer at the top and bottom of the vessel with different in the sizes of the ceramic ball. This material is slightly like the sand filter system for water purification.

It is also non-reactive and this statement was supported by Rakannusa (2012), which said that it has a unique biological application due to their nature of non-reactive to human and internal system. For example, it was been applied to internal medicine to treat several human and animal dysfunctions. In this case, it would be impossible to use steel due to the chemical present inside the human body which eventually will cause corrosion to the steel.

2.2 Raw Material in the Ceramic Ball Production

2.2.1 Feldspar

Feldspar is by far the most abundant group of minerals in the earth's crust, forming about 60% of terrestrial rocks. Most deposits offer sodium feldspar as well as potassium feldspar and mixed feldspars (IMA-NA 2012). Feldspars are primarily used in industrial applications for their alumina and alkali content. The term feldspar encompasses a whole range of materials. Most of the products we use on a daily basis are made with feldspar: glass for drinking, glass for protection, fiberglass for insulation, the floor tiles and shower basins in our bathrooms, and the tableware from which we eat. Feldspar is part of our daily life. According to Indiani et.al (2012), Feldspar is a common raw material used in glassmaking, ceramics, and to some extent as a filler and extender in paint, plastics, and rubber. In glassmaking, alumina from feldspar improves product hardness, durability, and resistance to chemical corrosion. In ceramics, the alkalis in feldspar (calcium oxide, potassium oxide, and sodium oxide) act as a flux, lowering the melting temperature of a mixture. Fluxes melt at an early stage in the firing process, forming a glassy matrix that bonds the other components of the system together.

Figure 2.1 Various types of Feldspar

(Source: Wikipedia, 2012)

Feldspar is very important in a mixture of ceramic materials. Feldspar generally expressed in the form:

$$\mathrm{KxNa1} - \mathrm{x}\left[\frac{Al}{SI3}\right]O8$$

In general there are 3 types of feldspar which are:

$$1. \mathrm{Arthose} = \mathrm{K}\left[\frac{Al}{SI3}\right]O8$$

$$2. \mathrm{Albite} = \mathrm{Na}\left[\frac{Al}{SI3}\right]O8$$

$$3. \mathrm{Anorthite} = \mathrm{Ca}\left[\frac{Al}{SI3}\right]O8$$

From its composition, it can be seen that Feldspar structure is not totally different with the structure of the clay, a natural silicate, pink or brown in colour and is the ceramic mineral with one of its composition is $NaAlSi_3O_8$. Feldspar is also a silicate network and among of the four silicon atoms in which replaced by aluminum atoms. At temperatures of 900^oC, Feldspar are generally stable and do not undergo a phase change.

2.2.2 Kaolin

In its natural state kaolin is a white, soft powder consisting principally of the mineral kaolinite, which, under the electron microscope, is seen to consist of roughly hexagonal, platy crystals ranging in size from about 0.1 micrometre to 10 micrometres or even larger. These crystals may take vermicular and booklike forms, and occasionally macroscopic forms approaching millimetre size are found. Kaolin as found in nature usually contains varying amounts of other minerals such as muscovite, quartz, feldspar, and anatase. In addition, crude kaolin is frequently stained yellow by iron hydroxide pigments. It is often necessary to bleach the clay chemically to remove the iron pigment and to wash it with water to remove the other minerals in order to prepare kaolin for commercial use.

When kaolin is mixed with water in the range of 20 to 35 percent, it becomes plastic (i.e., it can be molded under pressure), and the shape is retained after the pressure is removed. With larger percentages of water, the kaolin forms a slurry, or watery suspension. The amount of water required to achieve plasticity and viscosity varies with the size of the kaolinite particles and also with certain chemicals that may be present in the kaolin. Kaolin has been mined in France, England, Saxony (Germany), Bohemia (Czech Republic), and in the United States, where the best-known deposits are in the southeastern states.

Figure 2.2 Kaolin

(Source: Perpis International Co., 2012)

Kaolin is used extensively in the ceramic industry, where its high fusion temperature and white burning characteristics makes it particularly suitable for the manufacture of whiteware (china), porcelain, and refractories. The absence of any iron, alkalies, or alkaline earths in the molecular structure of kaolinite confers upon it these desirable ceramic properties. In the manufacture of white ware the kaolin is usually mixed with approximately equal amounts of silica and feldspar and a somewhat smaller amount of a plastic light-burning clay known as ball clay. These components are necessary to obtain the proper properties of plasticity, shrinkage, vitrification, etc., for forming and firing the ware. Kaolin is generally used alone in the manufacture of refractories.

Kaolin is classified into two types: first a precipitate residue which comes from the changes in the rocks. Second is the type of precipitation which nice stone and clay particles have been separated from the sediment. Kaolin derived from the preshidrotermal in which erosion occurs due to the effect of hot water contained in fractures and faults as well as the other permeable rocks. According to Sihite (2008), kaolin derived from the weathering (sedimentation) and the weathering of igneous rock that metamorpik reaction is as follows:

$KAlSiO_8 \longrightarrow HAlSi_3O_8 + KOH$ (Hydrolysis)

$HAlSiO_8 \longrightarrow HAlSi_3O_4 + 2SiO_2$ (Deslikation)

$2HAlSiO_4 + H_2O \longrightarrow (OH)_4Al_2Si_2O_5$ (Hydration)

2.2.3 Silica

Silica is one of the minerals that form perfect crystals, consisting of Crystals of silica (SiO2). Silica is the result of weathering processes contains major minerals such as Al_2O_3, Fe_2O_3, Cr_2O_3, Na_2O_3, TiO_2, K_2O. It is translucent white in colour, possess certain physical and mechanical properties.